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## Comment on "Application of BEM with extended Kalman filter to parameter identification of an elastic plate under dynamic loading" by M. Tanaka, T. Matsumoto and H. Yamamura [Engineering Analysis with Boundary Elements 28 (2004) 213–219]

In a recent paper, Tanaka et al. [1] successfully applied the boundary element method (BEM) for analyzing the elastic plate subjected to dynamic loadings to the corresponding inverse problems. They assumed that the lateral displacement of the plate is measured at eight points in the plate domain. Based on these measured data, they employed the extended Kalman filter (EKF) through iterative computation to update the parameter values. The authors provided two numerical examples to demonstrate that their method can be applied even if some measurement errors are included in the measured data. We found that there are three problems involved in their paper. Thus, the purposes of this comment are to suggest: (1) an approach to add hypothetical errors in generated error-free measurement data, (2) different forms of dynamic load to be applied to generate the plate deflection, and (3) the use of wider range of initial parameter values when applying EKF to their inverse problems.

Though the mathematical models cannot simulate the real world perfectly, i.e. there are always unavoidable noise, the EKF can provide excellent estimation results because it considers the statistic of the noise by adding system noise and measurement error in the state–space formulation. There are three kinds of error involved in the EKF algorithm, i.e. system noise, measurement error, and estimation error. In Tanaka et al.'s paper [1], the system noise in Eq. (20) is set to zero and the estimation-error covariance matrix $P_{k/k-1}$, appeared in Eqs. (24) and (26), is assumed to be a constant at the step $k=0$. They then computed the measured data by the BEM combined with Laplace transform [2] and used different error covariance $R$ (0, $10^{-13}I$ and $10^{-14}I$) in the EKF algorithm to demonstrate that the noisy measured data did not significantly affect the identified results. However, such an examination of measurement error seems to be incorrect. The measurement error in the observation equation, Eq. (21), was zero since the measured data they used were directly obtained from the BEM combined with Laplace transform. Accordingly, the measurement error covariance $R$ should also be zero during the identification processes. For testing whether the EKF can pursue proper estimated results even under the condition that the data contains minor error, the authors can refer to the article by Leng and Yeh [3] in which the measurement errors are represented by white noise or correlated noise and added to the measurement data. Leng and Yeh [3] also examined the effect of the measurement errors on the estimation result. We believe that the BEM combined with EKF should be capable of obtaining great estimation results even the measured data contain errors.

We herein suggest using different dynamic loading functions to generate different types of displacement. In the second example, Tanaka et al. [1] used a loading represented by the product of a constant loading $P_0$ and Heaviside function $H(t)$, which indeed was a constant loading instead of a time varying loading (dynamic loading). They mentioned in Section 4 that the results of the first numerical example were very great for the dynamic loading ($P=50\sin 40\pi t+50$ (N)) case. Since the BEM combined with EKF is very powerful to the inverse analyses, we suggest that for the second example they might use a dynamic loading such as a modified $P$ with different amplitude or frequency from the first example, the transmission pulse of Jiang et al. [4], or impulsive loading used in Li et al. [5].

Finally, we would like to discuss the choice for the initial parameter values when applying the EKF. Knopman and Voss [6] pointed out that the information about the physical parameter may be most accurately obtained at points in space and time with high sensitivity. For the most sensitive parameter to the mathematical models for engineering problems such as Young's modulus to the material and the transmissivity to the groundwater flow, EKF generally allows a fairly wilder range of initial guess. Tanaka et al. [1] provided six different initial values of Young's modulus ranging from $1.0\times10^{11}$ to $3.0\times10^{11}$ and the target value is $2.0\times10^{11}$. Leng and Yeh [3] demonstrated that the initial guess of the transmissivity $T$ can range from 100 to 3000 $m^2$/day whereas the target value of $T$ is 1139 $m^2$/day. Based on our experience, the EKF can identify the major parameter without loss accuracy even the guess value is one order of magnitude less than the target value.

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